CLAIMS

1. A method of conserving battery energy used in transmitting signals carrying data from a downhole location, using a transmission system where a predetermined set of data is to be transmitted once during a predetermined period, the method comprising the steps of:

transmitting at least one signal during said period to transmit the set of data;

selecting the time of transmission of said at least one signal; and

representing at least some of the data to be transmitted in terms of the time of transmission of said at least one signal.

2. A method according to claim 1 comprising the further steps of:
determining the data size of the predetermined set of data;
determining the transmission characteristics of the channel over which the data is to be transmitted; and
selecting at least one of:
1) the number of signals to send during the predetermined period;
2) the duration of each signal;
3) the power of each signal; and
4) the quantization of the predetermined period,
so as to allow transmission of the required data during the predetermined period whilst minimising the battery energy used.

3. A method according to claim 1 or claim 2 in which there is a plurality of sets of data, each of which is to be sent once during the same predetermined period, the method comprising the step of using signals having different frequency characteristics to carry respective sets of data such that the signals

are distinguishable from one another.

4. A method according to any preceding claim in which the transmission system is such that a set of data is to be transmitted once during each of a plurality of successive predetermined periods.

5. A method according to claim 4 wherein said predetermined periods are contiguous.

6. A method according to any preceding claim when dependent on claim 4, wherein the method comprises the steps of transmitting a first, reference, signal within each predetermined period and transmitting at least one further signal, as a data signal, at a selectable time relative to the reference signal within each predetermined period.

7. A method according to claim 6 in which the reference signal is sent at a preset time in each period.

8. A method according to claim 6 or claim 7 where there is one data signal in each predetermined period and the method includes the steps of:

considering the time period between the data signal of one predetermined period and the reference signal of the same period together with the time period between the data signal of that predetermined period and the reference signal of an adjacent period and;

using a ratio of these two time periods to give a value representing at least some of the data to be transmitted.

9. A method according to claim 8 where there are a plurality of data

signals in each time period, and the method comprises the step of using a plurality of ratios to encode data.

10. A method according to any preceding claim in which the reference signals are made distinguishable from the data signals.

11. A method according to any preceding claim in which the data is represented digitally and the predetermined period is quantized appropriately such that different timings represent different digital values.

12. A method according to any preceding claim wherein a clock is provided at the transmitting location and a clock is provided at the receiving location respectively for use in encoding and decoding data and the method comprises the step of transmitting a periodic reference signal and using this to calibrate the clocks one against the other.

13. A method according to claim 1 wherein, a plurality of data signals are transmitted during said predetermined period; each data signal has an associated frame within said predetermined period and during which the respective data signal may be sent, the time of transmission of the data signal within that frame representing at least some of the data to be transmitted; and the respective associated frame of at least one of the data signals overlaps in time, at least in part, with the respective associated frame of another of the data signals.

14. A method according to claim 13 in which the frames are such that the respective frame associated with each data signal overlaps in time, at least in part, with the respective associated frames of each of the other data signals.

15. A method according to claim 13 or claim 14 in which the predetermined period comprises a data signal period which can be occupied by frames of data signals, this data signal period is divided into equal length time slots, which are of equal length to time slots in the frames and the number of equal length time slots in the data signal period equals the sum of the number of data signals to be sent during the predetermined period and the number of equal length timeslots in each frame.

16. A method according to any one of claims 13 to 15 in which at least one frame is discontinuous in time.

17. A method according to any one of claims 13 to 16 comprising the further steps of:
splitting the set of data to be sent into data subsets;
transmitting a respective data signal at a selected time within a respective frame in representation of each data subset, wherein the respective frames overlap such that the order of sending of the signals does not provide a positive indication of the data subset to which each signal relates; and
transmitting an auxiliary indicator which enables determination of the data subset to which each signal relates.

18. A method according to claim 17 in which the step of transmitting an auxiliary indicator comprises the step of transmitting at least one decommutation signal which indicates the order in which the signals relating to the data subsets are being sent.

19. A method according to claim 1 or claim 13 in which there is a common frame within the predetermined period associated with a plurality of data

signals and within which the plurality of data signals are distributed in time.

20. A method according to claim 19 where there is a single common frame which substantially fills the whole predetermined period.

21. A method according to any preceding claim comprising the step of using a look up table in encoding the data to be sent.

22. A method according to claim 21 in which the look up table comprises entries in a form where specific data sets which can be transmitted are associated with unique signal arrangements.

23. A method according to claim 22 in which the look up table is populated in a way such that where X specific data sets are to be represented the X unique signal arrangements are chosen such that each includes the respective minimum possible number of individual signal pulses.

24. A method according to claim 1 which is used to conserve battery energy used by a downhole device in sending data items from a set of predetermined data items during a predetermined period, with a signalling regime comprising a modulation scheme where a data transmission period is divided into equal length time slots and there is a plurality of unique signal arrangements, each of which arrangements is associated with a respective one of the data items and wherein each unique signal arrangement has an associated pattern of pulses distributed in the time slots and the unique signal arrangements are selected so as to one of control and minimize, across the whole group of associated pulses, the mean number of pulses per associated pattern of pulses.

25. A method according to claim 24 comprising the further step of determining the shortest pulse period supported by the transmission channel to achieve the required signal to noise ratio and defining the time slots so as to have a length substantially equal to the determined shortest pulse period.

26. A method according to claim 24 or claim 25 wherein, the data transmission period is chosen to occupy substantially the whole of the predetermined period.

27. Downhole data transmission apparatus using battery energy for transmitting signals carrying data in a regime where a predetermined set of data is to be transmitted once during a predetermined period, the apparatus being arranged to conserve battery energy and comprising:
transmitting means arranged for transmitting at least one signal during said period to transmit the set of data, and control means for selecting the time of transmission of said at least one signal and arranged for representing at least some of the data to be transmitted in terms of the time of transmission of said at least one signal.

28. Apparatus according to claim 27 comprising computer means.

29. Apparatus according to claim 27 comprising computer means arranged under the control of software to carry out the steps of:

a) obtaining information regarding the data size of a predetermined set of data to be sent over a channel during a predetermined period, which set of data is to be sent using the steps of transmitting at least one signal during said period, selecting the time of transmission of said at least one signal, and representing at least some of the data to be transmitted in terms of the time of

transmission of said at least one signal;

b) obtaining information regarding the transmission characteristics of the channel over which the data is to be transmitted; and

c) selecting at least one of:

1) the number of signals to send during the predetermined period;

2) the duration of each signal;

3) the power of each signal; and

4) the quantization of the predetermined period,

so as to allow transmission of the required data during the predetermined period whilst minimising the battery energy used.

30. Apparatus according to any one of claims 27 to 29 which is arranged to transmit a plurality of sets of data once during the same predetermined period and to use different frequency characteristics to carry respective sets of data such that the signals are distinguishable from one another.

31. Apparatus according to any one of claims 27 to 30 which is arranged to transmit a set of data once during each of a plurality of successive predetermined periods.

32. Apparatus according to claim 31 in which said predetermined periods are contiguous.

33. Apparatus according to claim 27 arranged to transmit a plurality of data signals during said predetermined period, wherein each data signal has an associated frame within said predetermined period and during which the respective data signal may be sent, the time of transmission of the data signal within that frame representing at least some of the data to be transmitted; and

the respective associated frame of at least one of the data signals overlaps in time, at least in part, with the respective associated frame of another of the data signals.

34. Apparatus according to claim 33 in which the frames are such that the respective frame associated with each data signal overlaps in time, at least in part, with the respective associated frames of each of the other data signals.

35. Apparatus according to claim 33 or claim 34 in which the predetermined period comprises a data signal period which can be occupied by frames of data signals, this data signal period is divided into equal length time slots, which are of equal length to the time slots in the frames and the number of equal length time slots in the data signal period equals the sum of the number of data signals to be sent during the predetermined period and the number of equal length timeslots in each frame.

36. Apparatus according to any one of claims 33 to 35 in which at least one frame is discontinuous in time.

37. Apparatus according to any one of claims 33 to 36, in which the apparatus is arranged to:
split the set of data to be sent into data subsets;
transmit a respective data signal at a selected time within a respective frame in representation of each data subset, wherein the respective frames overlap such that the order of sending of the signals does not provide a positive indication of the data subset to which each signal relates; and
transmit an auxiliary indicator which enables determination of the data subset to which each signal relates.

38. Apparatus according to claim 37 in which the auxiliary indicator comprises at least one decommutation signal which indicates the order in which the signals relating to the data subsets are being sent.

39. Apparatus according to claim 27 or claim 33 in which there is a common frame within the predetermined period associated with a plurality of data signals and within which the plurality of data signals are distributed in time.

40. A method according to claim 39 where there is a single common frame which substantially fills the whole predetermined period.

41. Apparatus according to any one of claims 27 to 40 comprising data storage means carrying a look up table for use in encoding the data to be sent.

42. Apparatus according to claim 41 in which the look up table comprises entries in a form where specific data sets which can be transmitted are associated with unique signal arrangements.

43. Apparatus according to claim 42 in which the look up table is populated in a way such that where X specific data sets are to be represented the X unique signal arrangements are chosen such that each includes the respective minimum possible number of individual signal pulses.

44. Apparatus according to claim 27 which is arranged to send data items from a set of predetermined data items during a predetermined period, and is arranged to use a modulation scheme where a data transmission period is divided into equal length time slots and there is a plurality of unique signal

arrangements, each of which arrangements is associated with a respective one of the data items and wherein each unique signal arrangement has an associated pattern of pulses distributed in the time slots and the unique signal arrangements are selected so as to one of control and minimize, across the whole group of associated pulses, the mean number of pulses per associated pattern of pulses.

45. Apparatus according to claim 44 in which the time slots are defined so as to have a length substantially equal to a shortest pulse period that it has been determined can be supported by the transmission channel.

46. Apparatus according to claim 44 or claim 45 wherein the data transmission period is chosen to occupy substantially the whole of the predetermined period.

47. Apparatus according to claim 27 arranged to carry out a method according to any one of claims 1 to 26.

48. A computer program comprising code portions which when loaded and run on computer means cause the computer means to execute the steps of:

a) obtaining information regarding the data size of a predetermined set of data to be sent over a channel during a predetermined period, which set of data is to be sent using the steps of transmitting at least one signal during said period, selecting the time of transmission of said at least one signal, and representing at least some of the data to be transmitted in terms of the time of transmission of said at least one signal;

b) obtaining information regarding the transmission characteristics of the channel over which the data is to be transmitted; and

c) selecting at least one of:

1) the number of signals to send during the predetermined period;

2) the duration of each signal;

3) the power of each signal; and

4) the quantization of the predetermined period,

so as to allow transmission of the required data during the predetermined period whilst minimising the battery energy used.

49. A computer readable data carrier carrying a program according to claim 48.

50. A communication system comprising transmission apparatus according to any one of claims 27 to 47 and receiving apparatus arranged for receiving and decoding the transmitted signals.

51. A computer arranged to carry out a method according to any one of claims 1 to 26 or arranged under the control of a program according to claim 48.

52. A method of generating a modulation scheme to conserve battery energy used by a downhole device in sending data items from a set of predetermined data items during a predetermined period, the method comprising the steps of:

selecting a data transmission period within the predetermined period and dividing the data transmission period into equal length time slots; and

selecting a plurality of unique signal arrangements and associating each signal arrangement with a respective one of the predetermined data items;

wherein each unique signal arrangement has an associated pattern of pulses

distributed in the time slots and the unique signal arrangements are selected so as to one of control and minimize, across the whole group of associated pulses, the mean number of pulses per associated pattern of pulses.